1908MNRAS..69..126M

On the Determination of the apparent Diameter of a fixed Star.

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Some sort of an idea of the size of a fixed star may be formed from a knowledge of its parallax and of its magnitude, but astronomers have not felt justified in placing much reliance upon any estimate obtained in this manner. A comparison between the light of the Sun and that of a star is difficult because of the immense difference between them. Statements ascribing to α Centauri and Sirius intrinsic splendours equal to 2·3 and 63 times that of the Sun respectively can only be regarded as indications that the truth is probably somewhere in the neighbourhood of these numbers.

Whether these differences of splendour are due to differences of diameter or of the amount of light emitted by equal areas requires further observation, and a direct method of determining a star's apparent diameter is much to be desired. For this purpose those stars which periodically experience occultation by the Moon are the most favourably situated for investigation. It will be remembered that certain stars were first shown to be double by peculiarities observed during occultation, and the idea comes into the mind that it may be possible to subject the phenomenon of lunar occultation to a refined and expanded photographic examination by employment of the long, rapidly moving films which are used in the modern bioscope.

The time taken by the Moon to occult a fixed star has been described as "instantaneous," or "less than the twinkling of an eye," and in other terms also indicating the opinion that the time in question is at once inappreciable and immeasurable. Very minute intervals of time are, however, measurable. Sir Andrew Noble's chronograph measures $\frac{1}{1000000}$ of a second. Professor Worthington has recently photographed the splash formed by a drop of water in a time estimated to be $\frac{3}{1000000}$ second, which does not differ much from a light-kilometre.

The question then arises as to the time probably taken by the Moon to occult an average fairly bright star.

I had made a few calculations based upon parallaxes which astronomers regard as being reliable within a small probable error, and had found that the time might be $\frac{1}{1000}^{s}$, when I took the opportunity of consulting Professor Dyson. He assumed the star to have a parallax $0''{\cdot}10$, and to be of the same actual diameter as the Sun; this leads to an apparent diameter $\frac{1}{1000}''$, and the time taken by the Moon to effect a direct occultation would then be about $\frac{1}{500}^{s}$.

In a letter to me, dated 1908 November 1, Professor Dyson proceeds: "Thus exposures of $\frac{1}{1000}^{s}$ or rather less would be required. With the Astrographic (13 in. O.G.) telescope a star of $9^{m}{\cdot}0$ registers so as to give a measurable image in 10^{s}. A star of

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$4^{\mathrm{m}}{\cdot}0$ would be shown in $\frac{1}{100}$ of this, or $\frac{1}{10}^{\mathrm{s}}$. With a telescope like the 30-inch reflector at Greenwich the time of exposure could be shortened about 6 times, and this is as far as can be got—so that it is possible that a star of $1^{\mathrm{m}}{\cdot}0$ might be photographed in $\frac{1}{13} \times \frac{1}{6} \times \frac{1}{10}$, or $\frac{1}{780}^{\mathrm{s}}$. These figures are, of course, hypothetical; but with the largest telescopes a few of the brightest stars might be photographed in $\frac{1}{500}^{\mathrm{s}}$, I should think; and if the diameter were three or four times that of the Sun, a result might be got . . . but, as far as I can see, the limits within which the method is feasible will depend upon the size of the telescope and the sensitiveness of the plate, and not upon the mechanical difficulty of giving the exposures. It will only be necessary to move the plate so that a trail will be shown."

If we assume that the apparent diameter of the star is something like $\frac{1}{1000}''$, the time taken by the Moon to occult it would be about $\frac{1}{500}^{\mathrm{s}}$ if the star were in the line of motion of the Moon's centre. This direct occultation is the most unfavourable for the present purpose. In general, the occultation would be oblique and the time taken to occult longer.

If the radius of the Moon which passes through the star make an angle β with the direction of the Moon's motion, the time for the occultation to be effected would be $\sec\beta$ times that of direct occultation, as may be readily verified. Thus if $\beta = 60°$, the time would be doubled; if $\beta = 82° \, 50'$ the time would be multiplied by 8, and so on.

Assuming the Moon to have an unbroken outline, occultation is not possible if β exceeds a certain magnitude. If the Moon all but misses the star, the time taken to effect the occultation will be a maximum, and equal to

$$\sqrt{\frac{D}{d}} \cdot \tau$$

where D, d are the apparent diameters of the Moon and star respectively, and τ is the time in respect of direct occultation. This is, in fact, the maximum value of $\tau \sec\beta$; d being small compared with D. If it were possible to observe such an occultation, the time to be dealt with might be as great as one or two seconds. Failing this, favourable conditions might well give a time longer than $\frac{1}{100}^{\mathrm{s}}$.

Can this time be measured either by a moving film giving a trail, or by the separate exposures of the kinematograph?

On account of the rough edge of the Moon it is probable that many different occultations of the same star would have to be observed before information in regard to its apparent diameter could be deduced.

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